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Reed's paper, by a comparison of the empirical means of arrays with the theoretical means calculated from the regression equations, or by the use of Blakeman's criterion.*

Thus the calculation of the correlation coefficient, which by a practical method is a very easy task, should always be the first step in the analysis of the data. The nature of the regression line can then be determined in a convenient and really scientific manner.

(3) The bibliography given by Reed as "containing complete statements of the later development of work on the theory of correlation" is far from complete. A partial list of the omissions may be found elsewhere.†

This note is written with no desire to criticize the work of an individual writer, but merely in the hope of saving some beginner, who might follow Reed's suggestions, excessive and unnecessary labor in the calculation of the correlation coefficient, or misconceptions concerning the value or applicability of this most important statistical constant.

Cold Spring Harbor, N. Y. J. ARTHUR HARRIS.

COMMENT ON PROFESSOR IRVING FISHER'S ARTICLE ON THE "RATIO CHART."

The following remarks upon Professor Fisher's article in the *Quarterly Publications* for June are made without controversial intent and published rather as supplementary to than as critical of the statements made in the article in question. Where there is entire agreement, however, there is naturally little occasion for comment.

In the matter of terminology I do disagree with Professor Fisher, but that is hardly worth debating. The choice of the name "ratio chart," and the suggested opposition between "ratio" and "difference," is open to objection. Are not the curves in question currently and correctly known as logarithmic? Is it worth while to avoid this term simply because it, or the conception involved, is not familiar to the man in the street? All statisticians are acquainted with such curves, though many, it is true, feel them to be alien, just as some of them feel all graphic devices to be alien to their work. Should not the re-naming of a thing to make it popular be left to the commercial classes as a suitable mercantile, rather than a scientific or properly pedagogic, device? But, if the change means an improvement in our terminology, as regards either accuracy or adequacy, the case is different.

According to the usage with which I am familiar, statistical curves, and the diagrams constituted by them, are either arithmetic or logarithmic. Numbers and quantities are absolute or relative. Differences, also, may be absolute or relative. A relative difference is a species of ratio, and the relative difference that is most familiar, both as regards species and form, is the per cent. increase. But the ratio may as well be to a constant as to a changing base—the latter being the case of per cent. increases. Index numbers are a familiar example of a system of relative numbers where the ratio is to a constant base. In a general way arithmetical curves and absolute numbers are thought of as corresponding to each other, the latter being the graphic expression of the former. This is not quite true, though there is no particular harm in such an association of ideas, provided it be accepted merely as such. Index numbers are relative numbers, but a series of such numbers, as directly plotted, constitutes an arithmetical curve. But a more thoroughly *relative* graphic expression of quantity and quantitative relations is found in logarithmic curves. I am informed by a mathematician to whom I have referred this paragraph that my use of terms here is in conformity with current mathematical usage.

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*Blakeman, J. On Tests for Linearity of Regression in Frequency Distributions. Biometrika, Vol. 4, pp. 332-350. 1905.

†Harris, J. Arthur. An Outline of Current Progress in the Theory of Correlation and Contingency. Amer. Nat., Vol. 50, pp. 53-64, 1916.

The idea of the "ratio chart" as developed by Professor Fisher appears to correspond to that of relative numbers or rather, specifically, to per cent. increases. Such relative increases are so important in statistical analysis that a correlative graphic device properly claims an important place in statistical practice. It is true in a general way that logarithmic curves correspond to per cent. increases. The objection to an equation of the two is that per cents., though so serviceable, are fundamentally a clumsy and often misleading kind of relative number, while the logarithmic curve is a thorough and even elegant method of expressing quantitative relations where relative, rather than absolute, numbers are of fundamental significance—which is doubtless the more usual case in statistics. It is not a part of Professor Fisher's task to point out the limitations of per cent. comparisons, but the omission is significant if the reader gains the impression that the logarithmic curve is a translation of per-cent.-increase ratios into graphic terms. Relatively speaking, a 20 per cent. increase is not twice a 10 per cent. increase, and a 50 per cent. increase is not the equivalent of a 50 per cent. decrease. The defectiveness of the method of compiling index numbers formerly in use and recently abandoned by the United States Bureau of Labor Statistics was due to ignoring such facts. An increase of 20 per cent. in 10 years is not an average increase of 2 per cent. per year. These objections do not apply to the *logarithmic* expression of numerical relations. The peculiarity of the logarithmic curve—and of course the difficulty of understanding it—appears greater after considering these illustrative examples. But it should also be evident that this graphic and statistical device is much more worth mastering than it would be if it were merely the counterpart of numerical per cent. analysis. A true feeling for the significance of logarithmic curves is to be obtained only by studying and using them. But they are worth the trouble, and the limitations of per cent. analysis are the best proof of their worth.

Professor Fisher has passed rather too cursorily over a type of arithmetical curve in which the absolute numbers are not plotted directly, but instead per cent. indices: Per cent. indices are the quotients (with the decimal point moved two places to the right) of the absolute numbers, resulting from division by some constant, the average being frequently the most convenient divisor. The writer is in the habit of calling such curves per-cent.-index curves. It should be noted that they use *relative* numbers. But the difference of such relative numbers from the absolute series is merely the difference between the foot and the meter—or whatever other arbitrary standard of length happens to be most convenient at the time being for purposes of plotting and comparison. The only difference between such a curve and a plot of the absolute numbers is in the scale, the preliminary computation serving chiefly the purpose of adjusting and controlling the scale, especially in a way to put two or more series of numbers upon an entirely comparable basis. Obviously such curves are to be interpreted like other arithmetical curves, though the adjustment of the scale is such as to make it usually convenient to refer the variations to a 100 per cent. axis instead of to a zero base, this feature justifying the cutting-off of the lower portion of the diagram and the utilization of the available space to better advantage, as may be done with logarithmic curves. Curves plotted from series of per-cent.-indices, it should be noted, are already adjusted so as to be grouped at the center of the diagram, at least if the 100 per cent. point for each series is the average of the series. Thus the per-cent.-index method has many of the advantages of the logarithmic method.

But the logarithmic curve is unquestionably a superior order of graphic device, and the fact that it is not generally familiar and understood is rather occasion for calling attention to its value—of course making the necessary explanation of how it works and why it is used—than for avoiding it where it is really most appropriate. That it is not always most appropriate may be illustrated by the fact that comparative logarithmic curves of the growth of population in France and Germany in the last hundred years would not meet the needs of the dominant interest in such a comparison. The per-cent.-index curve probably serves better to express the variation of an electrical load around its average than does a logarithmic curve, since the kilowatt capacity required at the peak should not, for most purposes, be represented as less important, or as occupying a less length on the vertical scale, than the kilowatt required during the hours of light loading.

That the use and qualities of logarithmic and per-cent.-index curves are subjects of thought not new to the writer may be shown by the following references to the annual reports of the New York Public Service Commission for the First District, where such curves, accompanied by more or less comment, will be found.* Logarithmic curves: Vol. III for 1908, p. 296ff; III for 1910, p. 24ff and p. 40ff;† III for 1911, p. 57ff; III for 1912, p. 78ff; II for 1913 p. 82ff.† Per-cent.-index curves: Vol. III for 1913, p. 71ff; III for 1914, p. 59ff and 72ff; II for 1915, p. 195ff.‡

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*From 1911 on the graphic work and a large share in the analysis is by Mr. L. H. Lubarsky.

†Here both the vertical and the horizontal scales are logarithmic.

‡This diagram has other special features, but the per-cent.-index device is fundamental.